using remote sensing *to*

Monitor Sequestered Carbon

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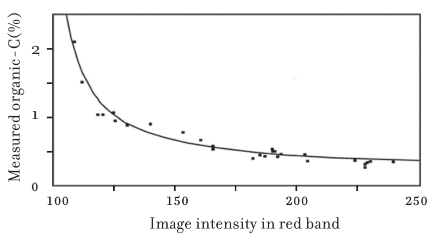
Introduction

Conservation tillage and sustainable agriculture practices are well known for their potential for carbon sequestration. Not only does carbon sequestration in soil have the potential to reduce greenhouse gasses, it also increases soil quality and long-term sustainability of soil. Soil carbon increases the soil's ability to fix and retain critical nutrients and moisture, thus increasing the net primary productivity and carbon uptake by vegetation. In order to assess and manage terrestrial carbon sequestration efforts in agriculture and natural environments, there must be some way to quantify soil organic carbon (SOC) across various landscapes. Accurate estimates and maps of organic carbon through reflectance-based models would be a great asset to land managers and policy makers in their efforts to balance the carbon source/sink equation.

Published Models:

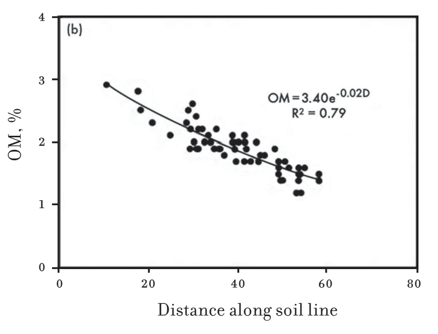
Soils rich in organic carbon are most often identified by their dark appearance. This property has caused most research to look at reflectance within visible bands to quantify and map carbon variability.



Feng Chen, et al. 2000

Intensity values of red, green, and blue were taken from aerial images of a study site in Georgia. An empirically derived linear logarithmic equation was fit to the collected data:

SOC = exp(a+bR+cG+dB)
R^2 = 0.9266



Fox 2002

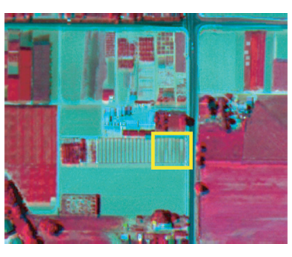
Used aerial imagery to create a soil line with Red and NIR intensity values. A pixel's distance along the soil line correlates with the soil organic matter (SOM) content.

Two recently published methods from Chen, et al. 2000 and Fox, et al. 2002 used visible red and NIR to predict carbon. Neither model, however, takes into account moisture variance.

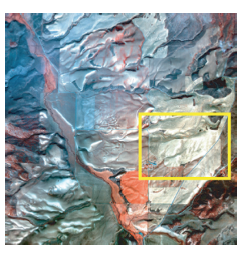
MODEL	IKONOS	QUICKBIRD
Chen	R^2 = 0.40	R^2 = 0.32
Fox	R^2 = 0.59	R^2 = 0.28

These models were tested using Quickbird and IKONOS imagery taken during the 2003-2004 season. *Both models failed to predict organic carbon to an acceptable level.*

Methods



Aerial image of the Greenville research farm, located in Logan, Utah, with designated plots marked



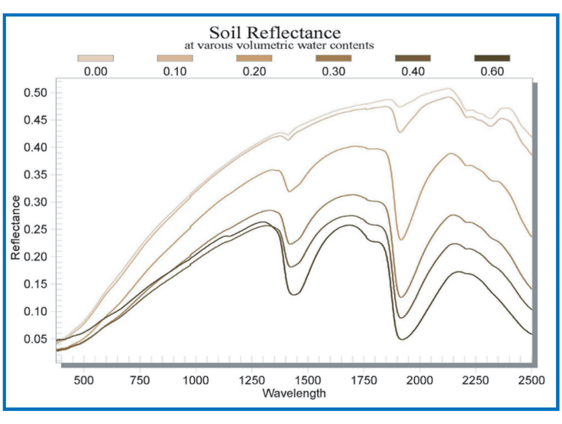
A Quickbird image of the Hans Hayden's farm in Arbon, Idaho

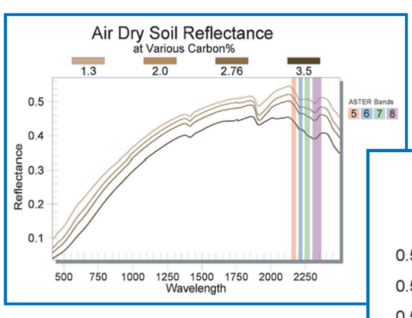
Our study looked at two different locations. The first was the Utah State University Greenville research farm, located in Logan, Utah. The second area of study was located in Arbon Valley, Idaho, on a farm owned by a cooperator, Hans Hayden, chair of the Idaho Wheat Commission. The Greenville experiment plots were used to analyze organic carbon's spectral response with moisture and to develop a model. Reflectance measurements were measured using an ASD spectroradiometer. The plots were made up of six strips divided into half, forming 12 sub-plots into a split-plot design, each receiving one of four compost treatments. Irrigation was applied through a line-source sprinkler irrigation system with continuously variable moisture.

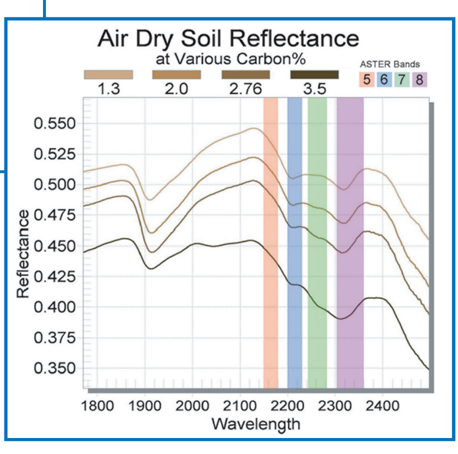
The Hans Hayden farm was used to validate the models because of its visibly light and dark (highly variable) soil types due to calcium carbonate and organic carbon differences.

Results

Spectral curve of soil reflectance at increasing volumetric water contents on a **coarse-silty, carbonatic, mesic typic haploxeroll** soil from the Greenville experiment plots



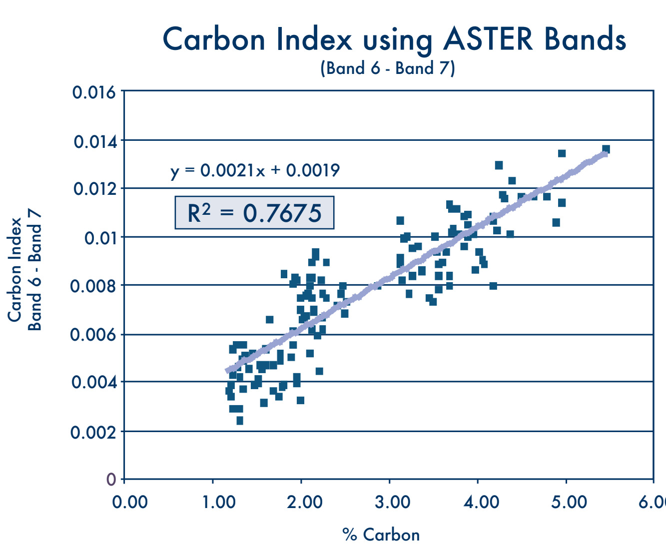




Spectral reflectrance of air dry soil with various SOC%. Note how reflectance differs within the highlighted ASTER bands 6 and 7

From the graphs it is apparent that both carbon and water decrease reflectance. However, water affects the SWIR bands differentially more than the visible bands. As water increases, it dominates all other absorption features throughout the spectrum. Organic carbon decreases reflectance almost uniformly across the whole measured spectrum. Reflectance around the 2250nm region does show a slight increase in absorption as SOC% increases. This band correlates well with Aster band #7.

New Model



Simulated ASTER bands using the ASD spectroradiometer were used to test the model on a **coarse-silty, carbonatic, mesic typic haploxeroll** soil. The test included a broad range of moisture and organic carbon values. There was a coefficient of correlation above $\mathbf{R^2 = 0.76}$

By calculating the differential between bands 6 and 7, an index is created that correlates well with organic carbon and is not affected by moisture.

CDI = Aster Band 6 - Aster Band 7

Discussion

Preliminary results show SOC can be estimated by using reflectance within the SWIR band. Since models based on visible bands tend to be confused with varying moisture content and low levels of SOC, it is anticipated that this model will be more robust within the Intermountain West where irrigation causes varying moisture within fields and SOC levels are very low. By utilizing a simple yet effective model to determine organic carbon, it is hoped that this will be useful in assessing world-wide terrestrial carbon inventories.

Aknowledgments:

Funding for this research was provided, in part, by: NASA/USDA "IFAFS" Grant (#NCC13-02001), DOE Southwest Regional Parthership for CO_2 Sequestration (#03-5139), and UAES Project#431.